Hey, You!

the CANNON

University of Toronto Engineering Society

SEE-YOU-IN-JANUARY ISSUE

December 7, 1978

GOOD LUCK WITH EXAMS!

Looking for trouble

Dr. R.A. Collacott,
Leicester Polytechnic

Imagine that every time you went to the doctor for a health check he insisted on opening up your stomach to see that all was well—and what is more, he did it every time you were ill, as well. Ludicrous? But this is just the sort of thing mechanics do when machines are not functioning properly. Sometimes they open them up after a specified number of running hours simply because someone has said this is the 'overhaul time': an exploratory operation on human beings every two or three years would be most unpopular.

Certain diagnostic techniques using sensors, inspection sids and analvtical procedures enable the 'health' of a machine to be discovered without time-wasting, dangerous and unnecessary strip-downs. Trouble can be predicted by comparing the information so obtained with reference data, and then measuring the amount of deterioration and finding out where it has occurred. In this way it is possible to forecast how long the machine will go on working and to know which component is beginning to fail, and possibly how.

there are three main ways of forecasting failure in machines and their value depends on the type of machinery and the kind of failure that most often occurs. They involve static, dynamic and performance tests. The static tests are non-destructive, of the sort used for inspection, in which the results are compared with reference data compiled when the machine was new. Dynamic tests use signals or waste products from the machine, relating them to effects of failure. Performance tests systematically relate changes in behaviour of the machine to its original performance.

These ways of forcasting deterioration and the onset of trouble can be used in process plant pressure vessels and heat exchangers, bridges, dams and other important structures. They are already in use and should, I believe, be made known to all designers and engineers so that facilities for applying diagnostic techniques can be incorporated in new equipment and structures.

Static Diagnostic Tests

Most machines are shut down from time to time when there is no work for them. It is

cont. on pg. 2

These radiographs, in which the light areas are mechanical components, reveal the disengagement of a turbine seal under one set of engine conditions and normal behaviour under another. The projecting platform on the rotating component, at the right of each picture, normally overlaps the shoulder of the other, static component. In the left-hand picture the components have moved apart axially and the seal no longer operates.

Prospects of Fusion Energy

cont. from last issue.

By G. Sinclair

President, Laser Fusion Investments, Inc., Concord, Ontario

Other applications of fusion energy

An important potential application of fusion is in hybrid fusion-fission reactors. Fusion can be used as a source of high energy neutrons to upgrade uranium or thorium to produce fuel for a CANDU reactor. In such applications, it may not be essential to achieve engineering breakeven (energy balance in the total system) since the sole criterion is the cost of the neutrons. It is possible that sufficiently low-cost neutrons can be produced from fusion.

Low cost hydrogen is obviously of interest in developing the Alberta tar sands. The crude petroleum extracted from the tar sands contains excess carbon, that is to say, it is devicient in hydrogen. The addition of hydrogen produces hydrocarbons which are useful products. Most present processes operate by removing the excess carbon, reducing the potential yield.

Another potential use for fusion is in transmitting the radio-active wastes produced by nuclear fission reactors. EPRI in the United States has made some studies of technical feasibility and concluded that fusion is a definite possibility for disposal of wastes.[10].

Conclusions

A review of the current status of fusion research and of its potential for producing energy has recently appeared[9]. The reviewer is quite pessimistic concerning the real potential of magnetic confinement schemes due to the magnitude and complexity of the engineering problems which need to be solved. The problems of maintenance of Tokamak type reactors are enormous, involving work on very large toroidal segments which have been rendered radioactove by bombardment by neutrons and alpha particles.

It is curious that the review had little to say on the subject of laser fusion, in view of the fact, as stated by the reviewer[9], that magnetic fusion will be allotted only $279 million out of a budget of

cont. on pg. 2

THE LURE OF THE SEA

DOWN TO THE SEA IN SIMULATORS

The sea can never be completey safe. The only way to be certain of avoiding shipwreck is never to go to sea. To maintain civilized life, people and goods must be carried about the world in ships, and occasionally an act of God destroys a ship. But are losses as few as they could be; do the acts of man cause them, too? Studies of marine accident statistics suggest that although losses are far lower than in the days of sail, they are still higher than they need be.

Various studies have shown that many more mishaps arise from human error than from equipment failure.

We can divide marine casualties into those from material causes—breakdown of engines or steering gear, say—and those brought about by human error of one sort or another. Various studies of the topic have shown that many more serious mishaps, such as groundings and collisions, arise from human error than from failure of equipment. This naturally leads to the question of what can be done to prevent human failures. How can we help the officers on a ship's bridge to avoid making wrong decisions as they go about the complicated business of navigating their ship from port to port, through storms and shoals, crowded shipping lanes and fog?

An obvious need is for good training. Foundations can be laid in the lecture room, but navigating a ship is in some ways like driving a car: you cannot fully learn the job by hearing about it or watching somebody else do it; you have to do it yourself. This raises few problems with a small vessel, in which a new officer can try his hand in quiet waters where a mistake or two would not be catastrophic. But would it be fair to the community to let him practise on a loaded tanker costing some 30 million pounds?

Similar learning problems are found in other industries, where expensive machines such as airliners or nuclear reactors are operated by human beings. The engineer's solution to the training problem is to build a simulator. By a simulator we

cont. on pg. 3

Fusion

cont. from pg. 1

$380 million for the upcoming fiscal year for laser and magnetic fusion. The review does mention that Canada's AECL Laboratories at Chalk River are working on a spallation source for generating neutrons. Spallation is a method for producing neutrons by conventional and relatively simple accelerator techniques. Existing accelerator beams need to be boosted from current of 1 ma to 300 ma. The spallation neutrons are to be used for breeding purposes.

The existing predictions of the time needed for fusion to become a commercial source of energy are quite confusing. Part of the confusion is the result of the diversity of opinion on how to solve the problem of conversion of the neutron energy to useful energy. The particular conversion method to be used has an important influence on the severity of the engineering problems to be solved, and therefore, on the time scale for their solution. KMS Fusion is apparently the only organization devoting a significant amount of effort to the question of conversion techniques.

It is a pleasure to acknowledge that the author derived much of his information from conversations with Dr. H. Gomberg of KMS Fusion, but the author takes full responsibility for the viewpoints expressed.

References

1. "Laser Fusion: a solution to the natural gas shortage". Hearing before a Subcommittee of the Committee on Government Operations, U.S. House of Representative, June 3, 197S. U.S. Government Printing Office.
2. Henry J. Gomberg, "Laser fusion at KMSI/KMSF". Annals of the New York Academy of Sciences, Vol. 267, Jan. 30, 1976, pp. 111-16.
3. H.A. Bethe, "The necessity of fission power", Scientific American, Vo. 234, No. 1, Jan. 1976, pp. 21-31.
4. R.F. Post and F.L. Ribe, "Fusion reactors as future energy sources**. Science, Vol. 186, Nov. 4162, Nov. 1, 1974, pp. 397-407.
S. J.D. Lawson, Proc. Phys. Soc. (London), B70 1 (19S7).
6. T. Kammash, "Fusion reactor physics", Ann Arbor Sci. Pub. Inc. Ann Arbor, Mich. 1976, p. 4.
7. James H. Krieger, "Strides made in laser fusion research", C&EN, March 29, 1976, pp. 21-2.
8. Keeve M. Siegel, "The energy crisis and a potential laser fusion solution", Jor. App. Sci. and Eng., Vol. 1, 197S, pp. 3-18.
9. "Fusion Research":
(i) Science, Vol. 192, 2S June, 1976, pp. 1320-23.
(II) Science, Vol. 193, 2 July, 1976, pp. 38-40, 76.
(III)Science, Vol. 192, 23 July, 1976, pp. 307-9.
10. Fusion Status Report, EPRI Jour., Sept. 1976, pp. 31-2.

I.E.E.E. PROMOTES PROFESSIONALISM

The student chapter of the I.E.E.E.(Institute of Electrical and Electronics Engineers) at the University of Toronto has experienced an increase in the size of its membership during the past year and the executive committee is expanding the list of activities for members in order to consolidate and continue this growth.

To describe the size and scope of the parent organization in this limited space would be difficult indeed. The I.E.E.E. has Groups and Societies concerned with virtually every aspect of Electrical Engineering from Quantum Electronics to Power, ranging in scope from a particular theoretical result to a broad application or managerial treatise. These Groups and Societies appeal not only to the formal Electrical Engineering Community but to specialists in other fields such as Computers, Physics, Chemistry, Materials Science, Mathematics, Industrial Engineering, Mechanical Engineering, Management, and others. Each of these Groups or Societies publishes journals, and the I.E.E.E. has survey periodicals (such as Spectrum) which cover the whole field of E.E. These periodicals are exceptional values both in financial terms (only $3 for students) and in terms of professional growth. for an interesting (if not unpredictable) article on the correlation between success in the profession and perusal of the literature the reader is referred to the September 1978 Issue of Spectrum.

Meanwhile other benefits originate from the student chapter itself. Aside from the obvious opportunity to meet with professionals and other students in a cordial and Informal manner at meetings, the student chapter has in the past year offered to its members:

- •A careers night to enable students to investigate various opportunities related to their course of studies.
- •Control '78, held in Toronto, as a representative of the chapter.
- •A microprocessor course consisting of lectures and practical experience with a kit based on the RCA 1802 Microprocessor. Due to its success, this course will probably be repeated in the near future.
- •Films and discussions on various technical topics, including an introduction to the Computer Research Facility.
- •Financial support for worthy projects such as a technical paper competition, and the Electrical Grad dinner.

In the near future the student chapter plans to offer:

- •A microprocessor-related design competition, open to all, but especially to the micro course participants.
- •A technical library and reading room, including most of the current literature published by the I.E.E.E.
- •A general EE design competition
- •Field trips to Control Data and Ontario Hydro Research, or interest to Engineers, as well as others.
- •A continuing series of speakers on various technical and general topics of interest to EE's.

The chapter president, Wayne Jannaway personally extends his invitation to all interested people in the University community to find out more by contacting their class reps, or by attending the executive meetings held on Thursdays at 4 p.m. in W8 316. Membership information is available in G8204, and at $10 yearly (includes subscription to Spectrum), this is one investment a serious student and aspiring professional Engineer shouldn't ignore.

Pieter Botman

Looking For Trouble

cont. from pg. 1

during these idle periods that diagnostic tests can best be done, though some have been developed for examining machines while they are running. The main types of static testing are shown in the table.

Recommendations as to the best methods to use are available from the Non-Destructive Testing Centre, UK Atomic Energy Authority, Harwell, which has made an assessment of all available techniques and is itself a pioneer n developing new and improved ones. For example, in a project with the Bristol Engine Division of Rolls royce (1971) Ltd, the NDT Centre used a linear accelerator with a large output of high-energy X-rays to photograph the insides of jet engines while they were running, and it was possible to measure changes in seal clearances and blade distortion. Commonly-used ways of inspecting the insides of engines or other spaces are by inserting miniature television camera probes, as small as 4.S mm diameter, embodying image intensifiers so as to inspect surfaces even in the poorest light. Modern developments in this field make it possible for a mechanic to insert the probe in places that are normally inaccessible to enable technicions to assess the internal condition from a television screen somewhere else. Several UK firms specialize in making these miniature surveillance cameras, and Mullard, decca and Rank are all involved in the development of image intensifiers.

Stress wave detection, now widely employed for inspecting pressure vessels, makes use of the well known phenomenon of 'tin cry', the crackling sound a stick of pure tin makes when it is being bent. Other materials behave in this way whenever they are strained. the Admiralty Materials Laboratory, near London, has developed apparatus to detect these waves and information about it is available from the UK National Research and Development Corporation (see page S).

Furnace insulation that is burning through and cold stores that are leaking cold air can be regularly inspected by infra-red scanning using the thermography technique. Because all matter gives off thermal radiation, a combination of radiatin pyrometry and television makes it possible to obtain a picture in colour of the heat coming from a surface. Poor insulation of a furnace shows up as hot spots; in a bank of switches one that has failed shows up as a cold spot, as does leakage in a cold store.

Other examples of 'static' tests include 'sniffing' leaks with sensors that detect changes in the thermal conductivity of vapours (this is even used to locate bombs through the vapours given off by explosives) and assessment of the rate of corrosion on structures exposed to the sea, which is done by detecting electrochemical voltages.

Best known of all the ways of sensing faults is vibration testing. Signals created by the movement of components make it possible to measure the amount of vibration when parts wear, and to assess amount of wear b how much the vibration increases. To obtain more precise information the vibration signals can be resoved into frequency bands by filters or other electronic means, to show the frequencies of peak vibration. When a frequency relates to a natural vibration of the machine, it becomes possible to identify the component that is in trouble.

Bearings for rolling parts are particularly important components because if they fail it might cause a lot of damage. Fortunately, a technique known as shock pulse monitoring is especially suitable for them. Studies at such places as the Institutie of Sound and Vibrations, at the University of Southhampton, have shown that flaking of bearing surfaces causes shock pulses at frequencies between 28 and 40 Hz. Meters have been devised to count the pulses, and the extent of bearing damage can be assessed from increases in their rate.

Where vibratlan tests are not sensitive enough, the debris itself may give an indication of the rate of failure. The easiest way to monitor it is by fitting magnetic plugs in the oil circulation system, to pick up any 'oil contaminant' as it is called. The amount of debris collected is a measure of rate of deterioration and the source of the debris can be found by examining it under a microscope. Every time an aircraft of British Airways completes its flight a record is made of its magnetic plug debris count.

More precise, analytical diagnoses can be made by using a spectrometer to measure the concentrations of small smounts of metal in samples of used oil. Metal particles are carried away after machine wear, so regular records of their concentrations disclose the amount of wear, corrosion and leakage. In an internal combustion engine, for example, iron particles that are present on their own come from cylinder liners or piston rings, while iron and silicon together indicate that sand is getting into air filters and blocking them.

Copper and lead together indicate wear of copper-lead bearings, and copper and tin together betray wear of bronze bearings. Chromates are present when coolant containing certain inhibitors leaks into a cylinder through cracks or an ill-fitting seal, and corrosion of silver-soldered pipe fittings gives traces of silver.

Engineers' logs were for many years the standard records from which chief engineers could assess the performance of engines. Modern power systems are too complicated for this procedure to be as effective as it used to be, but with complex machines that have automatic controls and a computer it is possible to use the computer itself to record the performance information and to compare it with stored reference data. The Queen Elizabeth 2 has such an installation, using advanced data logging techniques that incorporate an automatic scanning and alarm system. There is a monitoring system to examine various aspects of performance and provide information on the development of incipient faults. Similar techniques are used in some of the UK Central Electricity Generating Board's power stations. They are employed in chemical process plants, too, where heat transfer coefficients are continuously measured and compared with reference figures.

the 'black box' crash recorder which has to be fitted in all aircraft, known as Airborne Integrated Data System (AIDS), provides a basis for systematically assessing the performance for maintenance planning and for safety checks. Signals are fed to the box's recorder from sensors at strategic points and the recorded information is played back into a computer at the end of each flight. From this, evaluations are obtained of efficiency, rate of fuel consumption, intensities of vibration at significant frequencies and so on, all compared with reference data. The differences, or 'deltas', are recorded and diagnostic implications appear in a print-out. They are derived through logic interrogations of a binary kind which are fed into the computer and which are designed to relate known delta combinations to causes of failure.

To bring together specialists in the various technologies involved, I founded the UK Mechanical Health Monitoring Group based at Leicester. It meets from time to time to give all those interested in fault diagnosis and monitoring an opportunity to discuss their own problems and to hear others' experiences. Delegotes have come to these meetings from most European countries, the USA and the Far East. The wide range of interests covers heavy and light manufacturing industries, power generation, construction engineering, shipbuilding, petroleum refining, aviation, railways, public service vehicle operatio and even credit card systems.

cont. on pg. 4

cont. from pg. 1

simulators

mean a machine that can reproduce some of the functions of a larger machine or system so that it can work with a human being in the same way that the larger system does. It can then be used for training or drilling men to operate the larger system.

Advantages

Perhaps the first simulator ever used was the archery target. It enabled the bowman to perfect his skill without having to hunt out and risk retaliation from a human victim for every arrow. Other simulators used by the airlines for training flight-deck crews, particularly when graduating from one type of aircraft to another.

There are several important advantages in using a simulator for training. First, there is safety; a fall or two in learning to ride a bicycle does little harm, but mistakes in handling a real airliner or oil tanker would be intolerable. On the other hand, a navigator in a ship simulator can drive his 'ship' aground repeatedly, at no risk to life or the environment, until he gets the feel of avoiding sandbanks.

... the radar detects two ships ahead, one on a collision course. Just as the first ship's lights are seen, the instructor brings down a bank of fog ... the collision is avoided and the fog bank lifted, but as a buoyed sandbank appears close to starboard, he sees fit to jam the steering gear ...

Second, there is money. A simulator is probably, but not necessarily, cheaper in first cost than the system it simulates; it is certainly cheaper to run. Third, there is time. Using a real ship or an aircraft for training means time spent getting to the exercise area, seeking suitable weather, waiting for daylight and so on. In the simulator, the exercise can begin at the turn of a switch.

Last, and very important, the simulator gives complete control and repeatability of conditions. The instructor can set up whatever conditions of weather, visibility, surrounding traffic and so on that he wants. Moreover, these conditions can be repeated precisely, time and again, so that groups of trainees can be compared one with another in their response to a standard problem. This opens the possibility of using the simulator as an impartial device for testing and examing candidates for seagoing qualifications.

Handling Ships

Simulators reproducing the behaviour of marine radar sets have been in use in navigation schools in Britain for many years. The first ship handling simulators, incorporating a complete ship's bridge with a view through the window, were produced in the Netherlands specifically for training ships' officers in handling ships in the dredged approaches to the port of Rotterdam. The example set by the Dutch led to suggestions that the UK should have its own ship simulator.

Following discussions with the marine industries, the UK Department of Industry placed a contract with Decca Radar for the construction of the first ship simulator that would reproduce conditions at night. Now in full commission at the School of Navigation at Warash, near Southampton, it consists of a ship's bridge, complete with all the usual instruments—compass, radar, steering wheel, engine controls and so on— linked to a computer which is programmed to respond to Helm and engine orders in exactly the same way as a chosen ship. Characteristics of a number of ship types, ranging from a very large tanker to a small cargo vessel, and be selected at will.

The radar presents geographical information, including coast lines, islands, light houses, buoys and so on. A variety of 'geographies' are available, such as the approaches to Southampton, to Milford Haven, parts of the Persian Gulf, and certain synthetic areas laid out artificially to afford special exercises in seamanship. Geography and ship characteristics can be selected and changed rapidly. All the information about the positions of navigational lights and the ship data are held in digital form on magnetic-tape cassettes. The instructors can make up new tapes quite easily, and a library is being built up. Storing information in digital form has the advantage of enormous flexibility, in contrast to other simulation systems using physical models of harbours and coastlines.

Movement

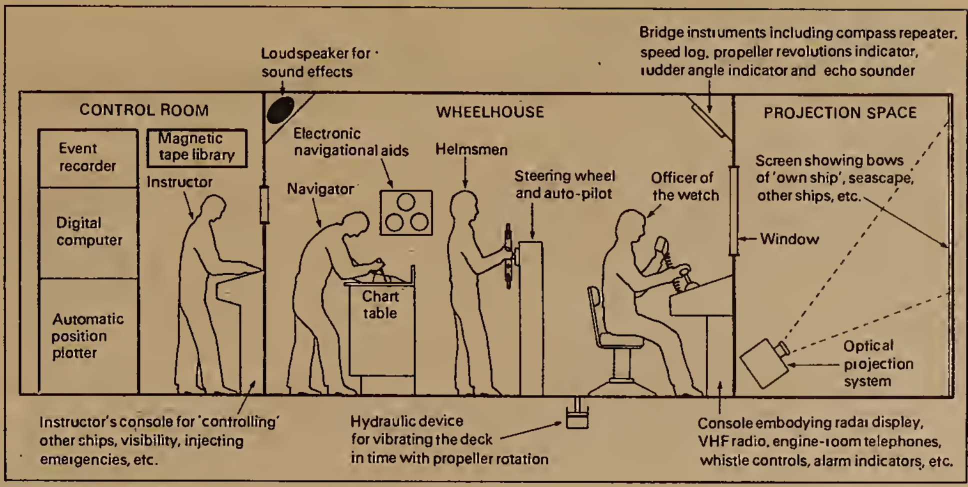
While the vessel moves, its radar, compass, propeller revolutions indicator and other bridge instruments give their proper indications in response to signals from the computer, which in turn answers to the steering wheel and engine controls. Through the windows can be seen the ship's foredeck, the night-time sea and sky, the lights of up to four othe ships, buoys, lighthouses and stars, and the moving wash from the ship's bow wave. The other ships are under the control of the instructor.

The scene is displayed by back profection on a translucent screen, far enough from the windows to make parallax effects imperceptible. The various points of white, red and green light come from a battery of optical projectors individually aimed by the computer. The distant rumble of the ship's engines is heard and the deck vibrates gently in response to the propeller at the correct number of cycles per minute. Changes in engine orders are followed, after a realistic pause, by the appropriate change in vibration: 'Full astern' produces an emphatic shudder.

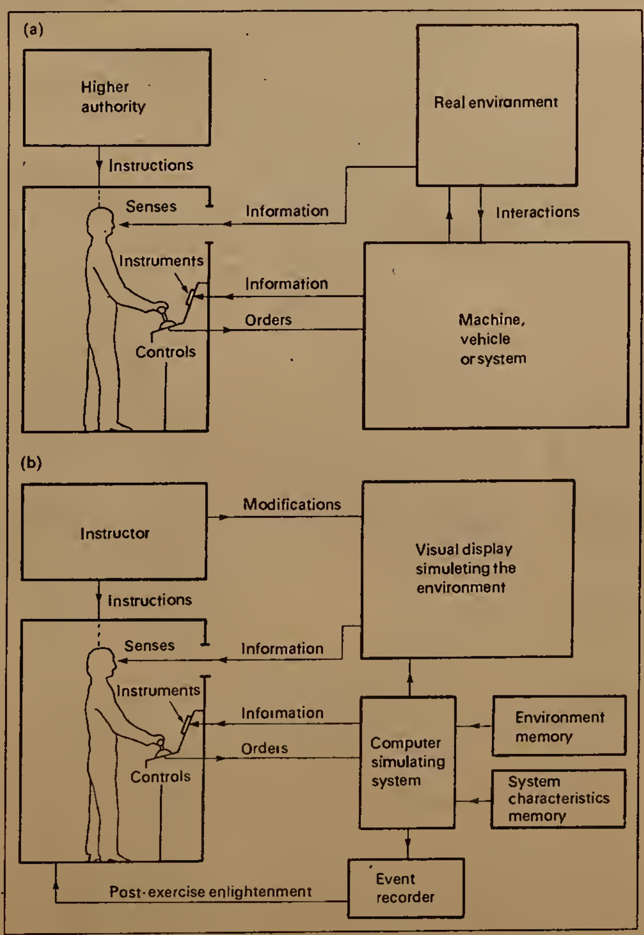
The overall effect is one of uncanny reality. In a typical exercise, the bridge is manned by three officers and a helmsman. To begin, the ship is steaming on a clear night down a fairway marked by lighted buoys. The officer on the radar reports a contact dead ahead, and soon afterwads the lights of an oncoming ship are seen. The officer of the watch calls for starboard rudder; the helmsman spins the wheel, the rudder indicator responds and the outside lights move across the window as the ship's head comes slowly round. The other ship shows her red steaming light and passes safely down the port side. Now the officer of the watch calls for port helm to clear a patch of shalows shown on his chart. The bell on the buoy marking the shoal water is clearly heord.

fog

Next, the radar detects two other ships ahead, one on a collision course; the instructor in the control room next door has decided to make life more difficult for his clients. Just as the first ship's lights are seen on the bearing predicted by the radar, he brings down a bank of fog and the lights disappear from view. The officer of the watch sounds the siren and the other ship's answering blast is heard. The range is closing rapidly. Rules of the road require the other ship to give way but the radar shows her on a steady course and a fixed bearing, a dangerous situation.



Arrangement of a ship simulator.



Comparison of (a) the usual relationships between man and machines and (b) those between man and a simulator.

the CANNON 978-5377

Associate Editors: Dona Williams, Rob Pupulin, Pete Rankin

"The Cannon is a journal of the University of Toronto Engineering society, and as such is published using student fees and distributed free to all Engineering buildings on campus. The Cannon is published to announce Engineering Society events, discuss Faculty and educational matters, present technical and University news and to be an open forum for the opinions and interests of Engineering students at the University of Toronto." All those who would like to help with your paper are welcome to. Submissions to the CANNON are also welcomed. They should be typed. The editors reserve the right to edit letters. The office of the CANNON is located on the Third Floor, Old metro Library, 20 St. George ST., Toronto, Ontario, M5S 2E4.

Engineering Society

Men in Engineering Crumpets and Tea Party

Jan 16, 1979.

Engineering Society

JANUARY 17 5 P.M.

full council meeting

GB 202

ALCHEMY IS NOT DEAD

The COKE machine again functions. By transmuting silver-nickel alloys into the form of disks into cold, thirst quenching fluids, packed in metallic container. In a reliable manner.

Support your favorite BNAD of Mary Makers by buying our pop.

Professional Development Committee Reps

The Professional Development Committee is pleased to inform the students of the Faculty of Engineering that they will be represented at this year's Canadian Congress of Engineering Students by the following students:

Ellen Rochman...............Chairman, Professional Develop·

Ellen Rochman...............Chairman, Professional Development
Nancy Brown.................Chairman, Social Committee
Mike Nettleton.............. Editor, Toike Oike
Heather Hayne...............Class rep, Mech III

To the other students who applied for delegate positions, I apologize. Financial constraints limited the number to four, a change from previous years. The delegates chosen are believed to be the most qualified for the job and have shown the most interest in Engineering Society activities in the past.

May I remind the students that the A.P.E.O. also sponsors a conference, which will be held this year at U.W.O., January 19-21, 1979. Anybody interested in attending should let me know early in January.

cont. from page 2
Looking for trouble

Because this is a new field of technology we have set up a special centre for fault diagnosis and monitoring at Leicester Polytechnic to provide courses of instruction for technicians on diagnosing faults in machinery such as air-conditioning plant, lifts, ships' engines, electrical circuits and telecomminications equipment. We also have a programme of research for postgraduates to develop improved ways of sensing conditions and preparing logic systems.